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(54) Title: METHOD FOR MARKING PAPER OR BOARD AND MATERIAL MARKED BY THE METHOD

(57) Abstract: The publication describes a method of providing paper or board with a marking that cannot be repeated after the paper has been detached from the paper machine and dried. The marking is made by focusing laser energy on the material fibres on the surface of an object in web form, or throughout its thickness. The invention also relates to marked paper or board, which can be manufactured by the method, or to a product that is obtained from the same by further processing.

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**Method for marking paper or board and material marked by the method**

The invention relates to a method of producing markings, which are difficult to forge, on a paper or board that is manufactured as a continuous web. The invention also relates to a paper or board product that contains markings provided by the method.

Methods of providing valuable paper products, such as banknotes, cheque forms, security forms, voting documents, lottery tickets, etc. or, on the other hand, individually custom-made identification documents, passports, driver's licenses, identification cards, and entry passes with markings, which make forgery on a small scale uneconomic or technically impossible, are known previously. Such markings have primarily been made on sheet-like paper by means of printing ink, engraving, pressing, cutting, perforating or notching. Conventionally, identification marks, e.g., watermarks, have also been made mechanically during the manufacturing process of paper.

The dynamic laser technology offers new methods of making extremely accurate markings without physically touching the surface that is to be marked or bringing more material on it, for example, printing ink.

While the effect of the laser beam is essentially directed on dry paper, various phenomena have been reported. An effective laser can be used in cutting paper, for example. US patent publication 5760369 shows a method of cutting and perforating paper by laser. By directing the laser beam at an angle, an effect is provided that cannot be provided by means of the conventional cutting dies.

According to the previous patent application FI 20040006 of the applicant, laser markings can be made by directing energy on the surface of a fibre layer by using a CO<sub>2</sub> laser beam of a lower power density. By using a CO<sub>2</sub> laser beam of a higher power density and an inert protective gas that prevents oxidation, cavities can be engraved into the fibre layer by evaporating the material, the cavities working as identification marks that can be detected by a detector in irradiation. The markings are made by the laser beam between the layers of a sandwich-type packaging material before the layers are brought together, so that the markings remain covered within the sandwich structure of the material. The layers can contain similar or different fibre layers, and also polymer films or coating layers that are typically used in the field.

When marking or cutting dry, completed paper, it is important to control the power, the intensity, and the speed of the laser beam to obtain a desired effect; however, in a controlled manner, avoiding non-desired effects, such as oxidation and the resulting discolouration. Sometimes, the colour changes are desired and, to provide  
5 them in a controllable manner, a fine-grained polymer additive is doped with the paper, as described in Patent Specification US 6306493. The said additive absorbs the energy brought by the laser by becoming charred, which is seen as a dark mark on the paper.

Marking of valuable paper products is described in patent publication US 4740269.  
10 A laser beam is used in making identification marks by partly removing the layer of colour or by forming an embossing on the said paper. To preserve the marks, thereafter, the paper must be protected by a coating.

US Patent No. 4824691 describes that, when making markings by a paper machine at moisture contents of 6 to 8% by weight, the energy brought by a low-  
15 energy laser ( $1.7\text{--}1.8\text{ J cm}^{-2}$ ) causes a local disturbance in the arrangement of fibres, which can be observed as a visible mark in the finished product. It was reported that higher energies ( $1.9\text{--}5.0\text{ J cm}^{-2}$  for a pulsed laser and  $2.2\text{--}4.8\text{ J cm}^{-2}$  for a continuous-wave laser) resulted in a disturbing scorching and darkening of the surface, which in the application of the publication, when making high-quality  
20 copying paper, is not acceptable from the point of quality.

Patent publication US 4824691 describes the marking of pressure-sensitive copying paper by the logo of the manufacturer or another identification mark. The accuracy and the clarity of the marks that were made on high-quality coated copying paper were examined as a function of several factors. The power of the laser  
25 beam and the moisture of the paper were observed to have an effect on the quality of the markings that were made in the dry end of the paper machine, so that the best results were obtained within a moisture range of 6 to 8% (the portion of water from the total mass).

The basic idea in the literature mentioned above was that, to protect the marking  
30 against attempts of forgery, or to make it difficult to make a forgery that would look authentic, the marking should be located under a coating or a surface layer so that the intactness of the surface material would be an indication of authenticity. However, the inventors of the present invention have surprisingly discovered that even single-layer paper or board can be marked so that the marking becomes suffi-  
35 ciently visible and durable without a separate coating or protective layer, but that it

is not possible to forge it on the completed paper, however. Of course, such paper or board can be coated later on or used as part of a sandwich structure, whereby its visible, marked surface functions as an identification. In that case, the other layers can be freely selected to serve other purposes and characteristics.

- 5 Thus, the object of the present invention is to provide a solution that enables the marking of paper or board, which is used as packaging material, in particular, by using laser energy to form an identification that is essentially more difficult to forge than before. The basis of the invention is that, at the packaging stage, instead of markings that are made on the complete package or a package that is being com-  
10 pleted, the marking is incorporated into the actual packaging material, paper or board at such a stage that it cannot be repeated on the finished product. By transferring the laser marking in the paper machine to a range of clearly higher water contents and lower solids contents, a marking is provided, which cannot be repeated after the material has been dried. The method according to the invention is  
15 essentially characterized in that the markings are made by the laser beam on a moving, wet fibre layer that is in the form of a web so that the markings remain visible after the paper has dried.

To be more precise, the object of the invention is defined in the appended claims.

### **Detailed description of the invention**

- 20 In the invention, the identification marks are made on the moving web in a paper or board machine at a typical manufacturing speed of the product (200 to 2000m/min). In other words, to make the marking, the speed does not need to be lowered, but when so desired, this can also be done. At the paper or board machine, the mark can be made at the web former, between the former and the dry-  
25 ing section, and in the drying section, between the drying units. At the time of marking, the solids content of the paper or board that is completed in the paper machine is preferably about 9 to 93% by weight. After the moisture has escaped from the paper, the identifier remains in sight, but it can no longer be altered or repeated too easily by a forger.
- 30 The phenomena, which take place on the fibre surface under the effect of laser energy, have been described, for example, in publication John F. Ready, Ed. in Chief; Laser Institute of America; 2001; ISBN: 0-912035-15-3, especially on pages 456-457. When cutting non-metallic materials, some fibres become plasmatic, evaporate away or break down chemically. For materials derived from wood, the

most typical is the chemical degradation, whereby the fibre exits as smaller components. It is said that cutting paper generates carbon dust and, thus, darkening occurs. The phenomena of the fibre level on a laser-marked surface are illustrated in Fig. 3. In the electron microscopic image, one can clearly distinguish single fibres, wherein part or parts in the middle of the fibre or at the end thereof are missing. Some material has escaped from the surface of the fibre layer.

At the low solids contents according to the invention, by increasing the laser power, fibre oxidation is provided, appearing as scorching and darkening. As a manageable and controllable phenomenon, the darkened spots provide a usable way of marking in packaging applications. Such markings are nicely visible in packaging materials, which have not been printed; however, the marking according to the invention does not prevent the further processing of the material by printing, for example.

The laser heads that are used in marking can be located, for example, in a stationary installed beam that is transverse to the web, producing onto the moving web a regular continuous or discontinuous pattern that suitably covers the web. The laser beams can also be focused on the web by means of the lens or mirror arrangements typical of the laser technology. The pattern that is used as the identifier can be any pictorial, literal or other trademark of the paper or board manufacturer, packager, or the manufacturer of the packaged product, for example, and it is most preferably specific to the product that is to be packaged. The selection of the stencils, frames or other means that are needed to define the pattern is evident to those skilled in the art.

When marking single-layer uncoated boards during the manufacture and before drying, the additives used are mixed with the pulp as early as in the head box and, typically, no other coating is applied. Such a marked and dried fibrous web can be combined with another layer already before winding onto a roll, or unwound on another line for lamination. The layer is preferably used as the surface layer, e.g., the inner or outer surface of packaging blanks which are to be formed into boxes or the like.

Accordingly, one application of the invention is a board comprising two or more superimposed fibre layers, the markings being made, before combining the layers, on either surface of the web-like fibrous layer that remains outwardly visible. At the stage of combination, the fibrous webs can still be moist, whereby the markings that remain on the surface exist already before the final drying of the combined

web at the board machine, and they will be inextricably integrated into the thus obtained, completed board.

5 A layer of coating paste or adhesive can also be added onto the marked and dried paper or board that is manufactured according to the invention, or a polymer coating that is combined by extrusion, for example, can be added to the fibre layer, both of which can optionally either be processed in the manufacturing process at the paper or board machine or in a separate coating unit subsequent to the same. By using the transparent polymer coating, the identification marks provided by removing fibres or discolouration can be left in sight, even if the marked layer was 10 not the surface layer of the structure. According to the invention, making the identification marks and the subsequent coatings are implemented as a continuous process without discontinuing the movement of the web, at the conventional speeds in the field.

15 The products obtained according to the invention comprise paper or board in web form, containing the identification marks and being provided with markings made by the laser beam, the markings being made on the wet web before the final drying of the product. Such a marked product can be manufactured on a large scale at the paper or board mill, from where it is supplied to a client company to be further processed. The paper or board obtained as the product can be further processed 20 by the methods typical of the field, and products similar to the known ones are obtained, containing the marking according to the invention. The material can be a single-layer or multi-layer board, coated paper or board or polymer-coated paper or board, and the markings can be visible on the surface layer or under the transparent polymer coating, or the markings can be under the coating or the fibre 25 layer, whereby they can be observed by transillumination or by a detector.

In the following, the invention is described in detail by means of examples and with reference to the appended drawing, wherein

30 Fig. 1 shows the marking of a web transverse to the travelling direction of the web former, by means of laser heads 3, which are attached to a supporting beam 2 and from which laser beams 4 are focused on the moving web.

Fig. 2 shows possible spots for laser-marking the fibrous material web, which is formed from the pulp coming from the head box, at a web former 5, between the web former 5 and a press section 6, in the press section 6 between press units 6A, 6B and 6C, or between the press section 6 and a drying section 7, or in the drying

section 7. The thickened arrows show the locations in the process, in which the laser marking can optionally be made and in which the laser-marking equipment in the process should be located.

Fig. 3 shows an electron microscope image including some of the laser-marked and unmarked fibre surface. In Fig. 3A, part of the marked text, the letter O, is shown as a 30x enlargement in the chemical pulp fibre described in Example 1. Fig. 3B shows a 500x enlargement, which allows a more accurate view of the changes caused by the effect of the laser energy on single fibres in the marking area. In the marked area, a considerable escape of material from the fibre structure is visible, caused by the effect of the laser energy.

Fig. 1 shows a fibre material web 1, the supporting beam 2 transverse to the web being placed in its way, and the identification marks that identify the web being produced onto the web by the laser beams 4 that are focused on the surface of the web from the laser heads 3 adjacent to the supporting beam. The marking can consist of a freely selected pattern, such as the name, identification image or trademark of the company or the product, and they form regular groups of patterns on the web at equal intervals. There should be enough markings on the web to cover each sheet or packaging blank that is later on selectively separated from the web.

The laser heads 3 in Fig. 1 can be CO<sub>2</sub> laser emitters, which have a low power density and which lightly burn the surface of the web 1 so that the identification marks comprise the darkening that is a result of the fibres evaporating, becoming plasmatic, burning and/or the fibre material oxidizing. Furthermore, it is possible that the laser beams 4 are used for reacting or evaporating the material selectively from a certain depth of the web, alternatively, or throughout the thickness of the web so that the density and/or the composition of the web changes at the marking spot with respect to the unmarked web.

Fig. 2 shows an extremely simplified flow chart, wherein the fibre material web is formed from pulp, which is fed from the head box, by means of the web former 5. Alternatively, the fibre material web can be marked by means of laser energy at the web former 5, whereby the fibre content of the pulp is very low, even below 10%. An alternative spot for making the marking lies between the web former 5 and the press section 6 before the liquid is removed from the web by pressing. Furthermore, the marking can be made in the press section 6 between the press units. The units are shown by naming them as press units 6A, 6B and 6C,

whereby the naming of the units is suggestive. Those skilled in the art will understand that there can be several press units one after another and the marking can be made between any units. One embodiment according to the invention is to make the marking after the press section 6 before the drying section 7 with respect to the travelling direction of the web, i.e., between the units. The marking can also be located in the drying section 7.

The product that is obtained as a continuous web may possibly further go through optional surface treatment 8 or further processing stages 9, 10, after which it is wound on a roll and the product 11 is supplied in the form of a roll, sheets, or blanks to be used as individual product packages that contain the identification marks.

The other material layer that is brought onto the marked fibre material web 1 can also consist of a polymer film that is laminated therewith, for example, or a single or multi-layer extruded polymeric coating. It is also possible to laser-mark the fibre material web 1 at the paper or board machine, whereby, at the next stage, the coating paste is brought onto the marked and dried web, covering the identification marks.

The invention is described in the following by means of application examples.

#### Example 1

A test was conducted in laboratory conditions, wherein a text marking was made on wet fibre material, chemical pulp fibre, by means of a 16W laser.

As a result of the laser marking that was made on the wet web, a visible trace was observed in the completed paper, a word trademark, wherein some fibre material had escaped from those spots, where the laser energy had been focused on, the paper was translucent and optically darkened.

The effect of the laser power on the fibre structure is illustrated by the electron microscope image that was taken of the interface between the marked and the unmarked areas, which is shown in Figs. 3 A and B.

#### Example 2

A test was conducted in laboratory conditions, wherein a marking was made on wet fibre material by a CO<sub>2</sub> laser. The solids contents and the powers of the laser beam that were used in the test series are shown in Table 1. The same table also

shows the results obtained by the said test arrangements. In the marking test series, the travelling speed of the laser beam was 500mm/s and the diameter of the focused beam was 290µm. Regarding the materials, the chemical pulp fibre refers to chemically defibrated softwood fibre without additives. The board herein comprises a 175g/m<sup>2</sup> sheet made of dried chemical pulp fibre (from bleached chemical pulp, and not from brown or chemi-mechanical pulp). The copying paper used in the test was a 80g/m<sup>2</sup> sheet made of chemical pulp, containing CaCO<sub>3</sub> as an inorganic additive.

Table 1.

Material	Solids, %	Power, W	
Chemical pulp fibre	9	20	Directly visible as slightly darkened, and also against light
Chemical pulp fibre	21	12	Directly visible as slightly darkened, and also against light
Board	44	12	A light mark, also visible against light
Copying paper	50	5	Visible in oblique light

In the sheet of chemical pulp fibre, which was dried after the marking and contained no additives, only fibre, the laser marking appeared slightly darker than its surroundings. The marking was also visible against light, because the effective laser beam removes fibres, and a spot of the marking that is thinner than its surroundings permeates light easier. The lower solids content, i.e., the fibre layer, which was to be marked and contained relatively more water, was marked by a higher power.

A less oxidized or lighter marking was obtained on the board, which had a solids content of 44% at the time of marking, by using the same power than for the more viscous chemical pulp fibre. The marking that is visible against light, however, indicates an escape of the material.

The marking that was made on the copying paper of a 50% solids content, was visible in oblique light only. Thus, the laser energy had changed the luminous reflectivity properties of the copying paper.

It is obvious to those skilled in the art that the descriptions of the invention are not limited to the above examples, but they can vary within the following claims.

Description of the reference numbers used in the figures:

- 1 Web
- 2 Supporting beam
- 3 Laser head
- 5 4 Laser beam
- 5 Web former
- 6 Press section with the press units 6A, 6B and 6C
- 7 Drying section
- 8 Optional surface treatment
- Processing
- 10 Calendering and winding
- 11. Product marked according to the method

## CLAIMS:

- 5 1. A method of making an identification mark of a paper or board product (11) by means of a laser beam (4), onto a fibre layer (1) formed as a web moving at a paper machine, **characterized** in that the marking is made on the wet fibre layer (1), after which the web is dried.
2. A method according to Claim 1, **characterized** in that the marking is made onto the fibre layer (1) by focusing laser energy on the material.
- 10 3. A method according to Claim 1, **characterized** in that the marking is made by removing fibres locally from the surface of the fibre layer (1) by means of the energy of the laser beam.
4. A method according to Claim 1, **characterized** in that the marking is made by removing fibres locally throughout the depth of the fibre layer (1) by means of the energy of the laser beam.
- 15 5. A method according to any of claims 2 to 4, **characterized** in that the marked fibre layer stays on the inner or outer surface of the completed product.
6. A method according to Claim 1, **characterized** in that the solids content of the fibre layer at the time of marking is from 9 to 93%, preferably from 20 to 50%.
- 20 7. A method according to any of the preceding claims, **characterized** in that the marking stage is located in the web former (5) of the paper machine.
8. A method according to any of the preceding claims, **characterized** in that the marking stage is located between the web former (5) and the  
25 drying section (7) of the paper machine.
9. A method according to Claim 8, **characterized** in that the marking stage is located between the web former (5) and the press section (6) of the paper machine.
- 30 10. A method according to Claim 8, **characterized** in that the marking stage is located in the press section (6) of the paper machine.

- 5
11. A method according to Claim 8, **characterized** in that the marking stage is located between the press section (6) and the drying section (7) of the paper machine.
  12. A method according to any of the preceding claims, **characterized** in that the marking stage is located in the drying section (7) of the paper machine.
  13. A paper or board product (11), which can be manufactured by the method according to any of the preceding claims and which contains identification marks and/or security symbols.

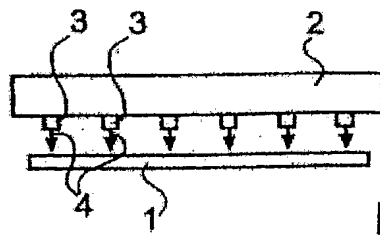


Fig. 1

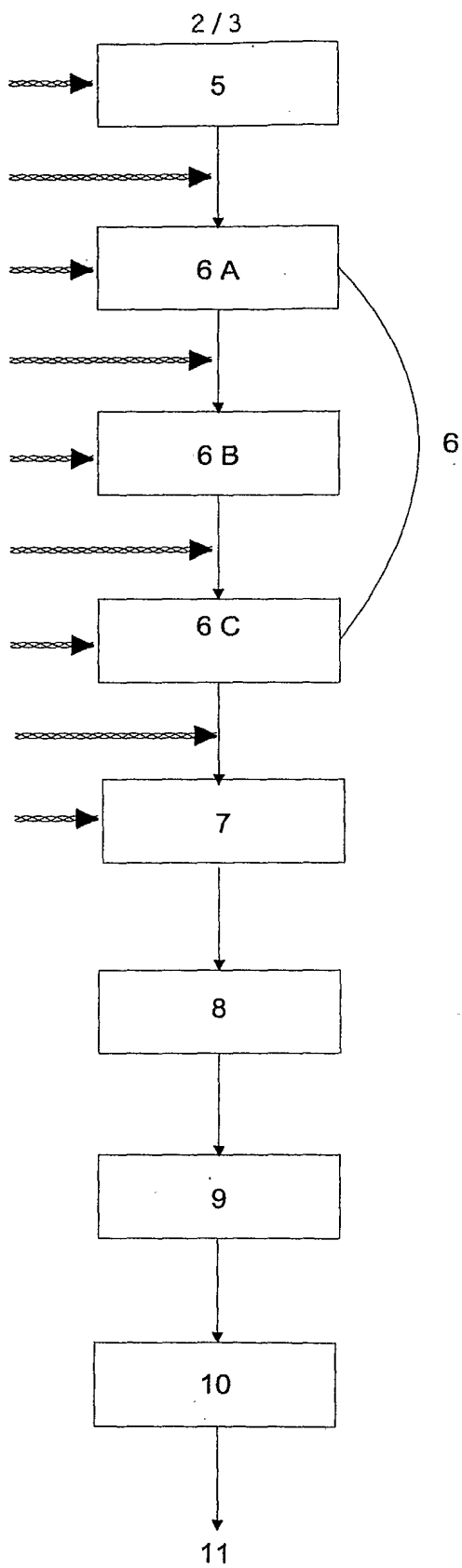


Fig. 2

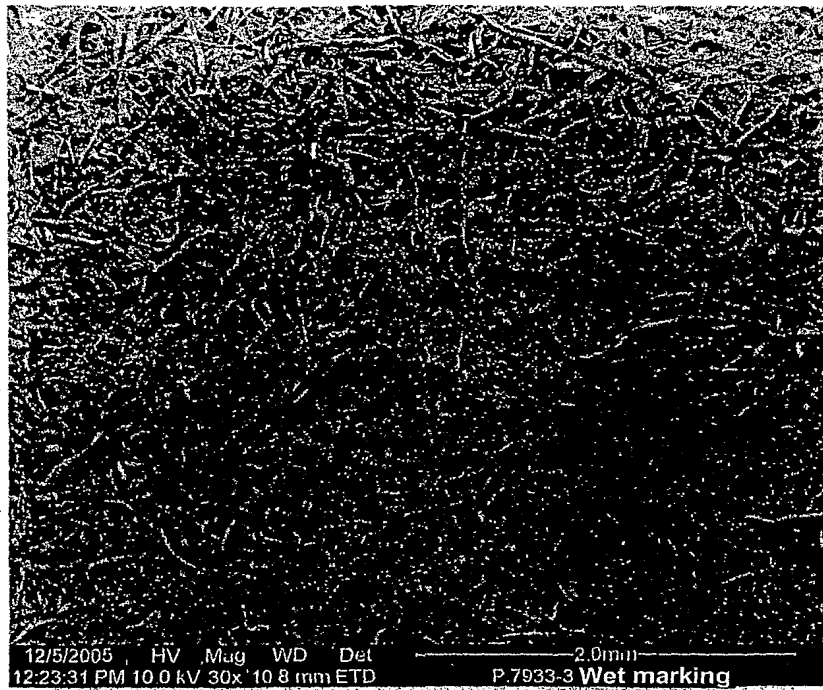


Fig. 3A

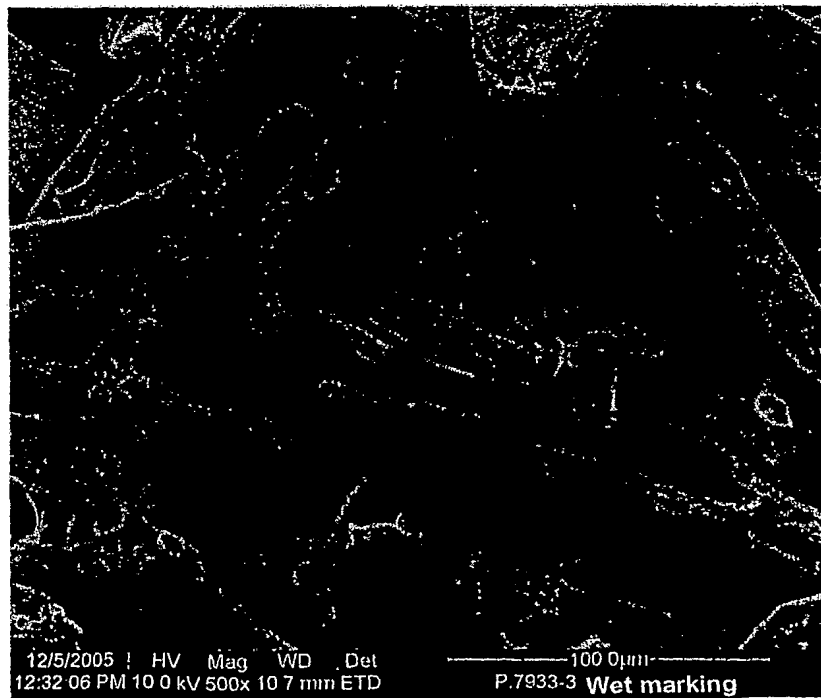


Fig. 3B

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/FI2007/000103

## A. CLASSIFICATION OF SUBJECT MATTER

IPC: **see extra sheet**  
According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: D21F, D21H, B41M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 3431577 A1 (HEINR.AUG. SCHOELLER SÖHNE GMBH & CO KG), 13 March 1986 (13.03.1986), page 11; page 15, line 1 - line 16, figure 1 --	1-13
X	WO 9960208 A2 (ZANDERS FEINPAPIERE AG), 25 November 1999 (25.11.1999), page 6, line 4 - line 7; page 14, line 20 - page 15, line 14 --	1-13
A	WO 2005065956 A1 (STORA ENSO OYJ), 21 July 2005 (21.07.2005), page 3, line 4 - line 8, claims 1,6 --	1-13

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

\* Special categories of cited documents:

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Date of the actual completion of the international search

15 August 2007

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## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4824691 A (TOWNSEND), 25 April 1989 (25.04.1989), column 3, line 12 - line 61 --	1-13
A	SE 503890 C2 (JAN-ERIK P NORDSTRÖM), 23 Sept 1996 (23.09.1996), page 10, line 30 - page 11, line 5 --	1-13
A	US 4740269 A (BERGER ET AL), 26 April 1988 (26.04.1988), column 2, line 51 - line 53, claims 3,4 --	1-13
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**B41M 5/24** (2006.01)  
**D21H 27/02** (2006.01)  
**D21H 27/10** (2006.01)

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Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

31/07/2007

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PAPER OR BOARD AND  
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**ABSTRACT:**

CHG DATE=20071102 STATUS=O>The publication describes a method of providing paper or board with a marking that cannot be repeated after the paper has been detached from the paper machine and dried. The marking is made by focusing laser energy on the material fibres on the surface of an object in web form, or throughout its thickness. The invention also relates to marked paper or board, which can be manufactured by the method, or to a product that is obtained from the same by further processing.